The content of this note is based on information received from manufacturers in the electrical and electronics industries or their representatives and does not imply practical experience by Elektor Electronics or its consultants.

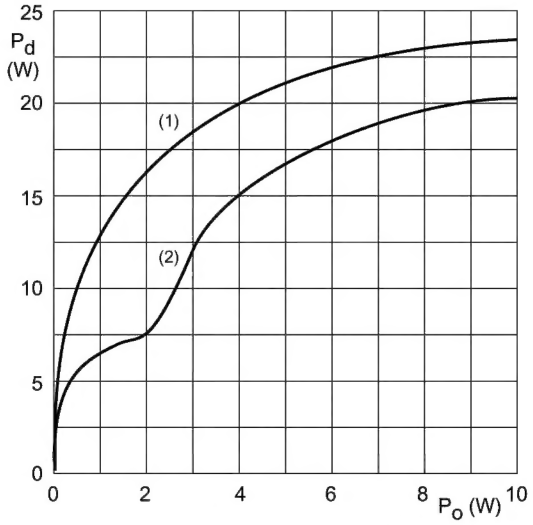
2 × 25 W Power Amplifier for Car Sound Systems

high efficiency with a TDA1563Q

Semiconductor manufacturers are always coming up with new techniques and tricks for making effective use of energy. Final amplifiers for car sound systems are no exception.

In designing power amplifiers for sound reproduction in vehicles, an output power of somewhat more than 6 W can be generated using a conservative class-B output stage. In spite of this relatively small output power, such stages are found in most car radios for the simple reason that class-B output stages have high efficiency (78.5% with a maximum-amplitude sine wave signal); the internal power dissipation is relatively small (20% of the output power). This avoids problems with excessive heat dissipation in the vehicle or the need to use an oversized heat sink, which arises from the fact that the maximum ambient temperature in a vehicle must be assumed to be considerably higher than with a home stereo system, for example, so a car radio cannot be allowed to run as hot.

So far, so good. However, nowadays you can't sell a car radio that 'boasts' a measly 2 × 6 W of output power. Manufacturers of car sound equipment have thus come up with several other ideas. The first remedy is to measure the output power under totally unrealistic conditions (100 Hz sine-wave signal, 18-V supply voltage and 10% THD). A quoted power of 30 W, for example, reduces to something more like 7-8 W under realistic conditions (audio signal, V_S = 13.2 V, THD = 0.5%). This is of course outrageous, but it's allowed by the Japanese EIAJ standard.



Input signal 1 kHz, sinusoidal; V_P = 14.4 V.

(1) For a conventional BTL amplifier.

(2) For TDA1563Q.

Figure 1. Comparison of a conventional bridge amplifier and the TDA1563Q. The new Philips IC clearly has lower power dissipation.

A second (and honest) possibility is to employ a switch-mode power supply to raise the supply voltage to (almost) any desired level. With this approach, it's no problem to obtain ear-splitting sound levels from the loudspeaker. However, a switch-mode power supply (which is normally housed together with the final amplifier in a single enclosure) takes up a lot of space and requires a hefty heat sink, which must dissipate the heat dissipated by the power supply in addition to that of the output stage. In a standard car radio bay, there is in any case not enough room for such a device.

Another way to produce more power is to use bridge operation. This requires two output stages, of which one is driven by the normal audio signal while the other one is driven by the inverted signal (via a phase inverter stage). The loudspeaker is connected between the two output stages, so that in comparison with 'single-ended' operation, the voltage swing is doubled and the output power is (theoretically) quadrupled. Unfortunately, the heat dissipation is quadrupled as well, which means a larger heat sink, increased heat dissipation and inefficient utilisation of battery capacity.

Nevertheless, manufacturers of car electronics make considerable efforts to outsmart the rules of physics using more or less sophisticated measures. These are based on the assumption that under normal circumstances the output power of an efficient class-B output stage is fully adequate, even for loud reproduction levels, with the limits being exceeded only by transient peaks. This means that what is necessary is to make sufficient energy available to achieve a higher output power level for brief intervals.

In the March 1995 issue of *Elektor Electronics* we reported an amplifier IC with the part number TDA1560Q, which has a sort of internal charge pump that can nearly double the supply voltage for brief signal peaks. In theory, this allows an output power of 26 W to be produced (although in practice, the value is a good deal lower). As ingenious as this technique may seem at first glance, a look at the distortion figures gives a different impression. When the supply voltage changes levels, the output stage generates strong, clearly audible distortion, which is naturally very irritating at loud reproduction levels (with correspondingly frequent switching between supply voltage levels).

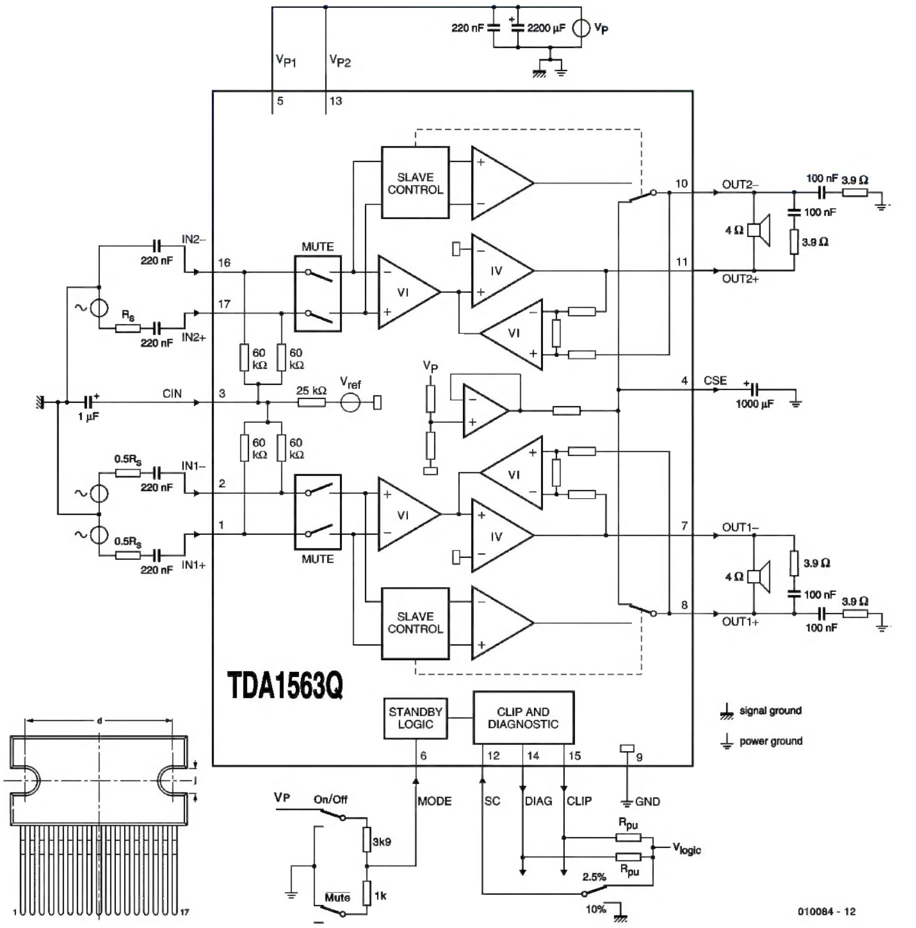


Figure 2. Inner circuitry and sample application for the TDA1563Q.

Less energy and smaller heat sinks

Philips has now developed a new concept in the form of the TDA1563Q. The output stage works in class-B mode as much as possible, which means that the ac signal works against half of the supply voltage. In this region, the efficiency is especially high. However, if the effective output voltage rises to more than 3 V, the IC switches to the bridge mode. Although this is not as efficient as the class-B mode, it achieves an output power of up to 20 W per channel with a realistic supply voltage and an acceptable level of distortion.

Figure 1 shows a plot of the relationship between output power and power dissipation with a 1-kHz input signal. The upper curve is for a conventional bridge amplifier and the lower curve for the TDA1563Q. The kink in the curve resulting from the changeover point is clearly recognisable. For single-ended operation, the power dissipation is less than half that of a normal bridge amplifier. If a Gaussian distribution of the output amplitude is assumed for music signals, the power dissipation of a conventional bridge amplifier lies around 70% higher.

Besides the energy-saving effect, the improved efficiency has other consequences. A conventional bridge amplifier with a total thermal resistance (insulating washer and heat sink) of 1.5 K/W, an allowable die temperature of 145 °C at a maximum ambient temperature of 65 °C and a delivered output power of 6.5 W per channel requires a heat sink (for a music signal) with a thermal coefficient of

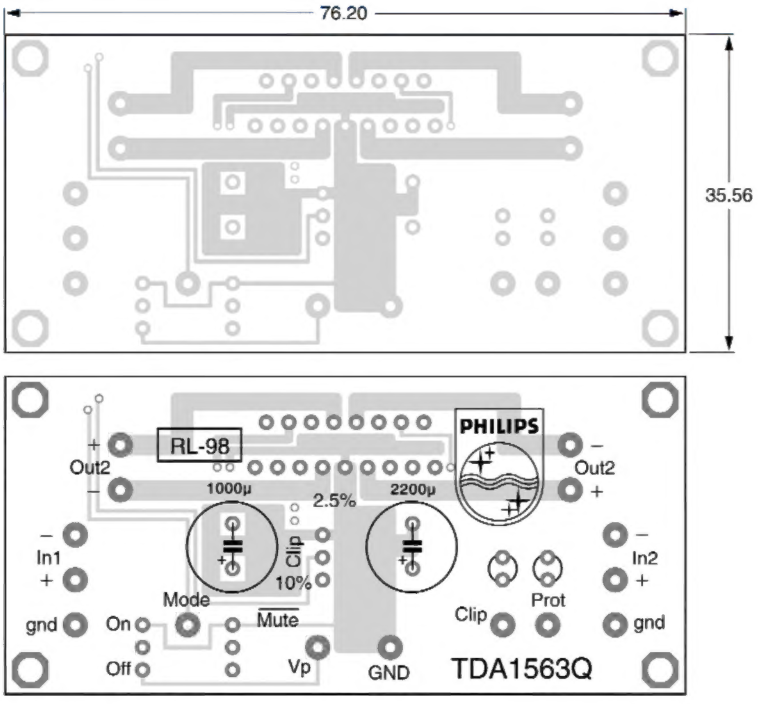
$$\Theta_{HS} = (145 - 65) \div (2 \times 6.5) - 1.5 \approx 4.6 \text{ K/W}$$

By contrast, the TDA1563Q with its 70% more efficient operation can manage with a heat sink having a thermal coefficient of

$$\Theta_{HS} = 1.7\ [(145 - 65) \div (2 \times 6.5)] - 1.5 \approx 9.0 \text{ K/W}$$

The heat sink can thus be kept significantly (!) smaller.

Figure 2 shows the internal circuitry of the TDA1563Q and a standard application circuit. The signal source (either balanced or unbalanced) is connected to IN+ and IN–. The manner in which an unbalanced (asymmetric) signal source is connected is shown in the upper diagram. The inverting input is tied to ground via a capacitor. The connections shown for the other channel are suitable for a balanced signal source. The resistors labelled 'R_S' simply represent the internal resistances of the signal sources. Since the combination of the internal resistance and the capacitor forms a high-pass filter, Rs is only of interest for calculating the lower cut-off frequency. The audio signal is applied to two amplifier stages that generate mutually inverted signals. One loudspeaker terminal is always connected to one of the output stages, while the other terminal is switched between the other output stage (for bridge operation) and the CSE (single-ended) pin by the Slave Control block. The CSE pin is held at half of the supply voltage level by a reference voltage source buffered by a 1000 µF electrolytic capacitor. An additional opamp, whose inputs are connected to the loudspeaker outputs, prevents dc offset voltages from appearing at the loudspeaker outputs.



Dimensions in mm.

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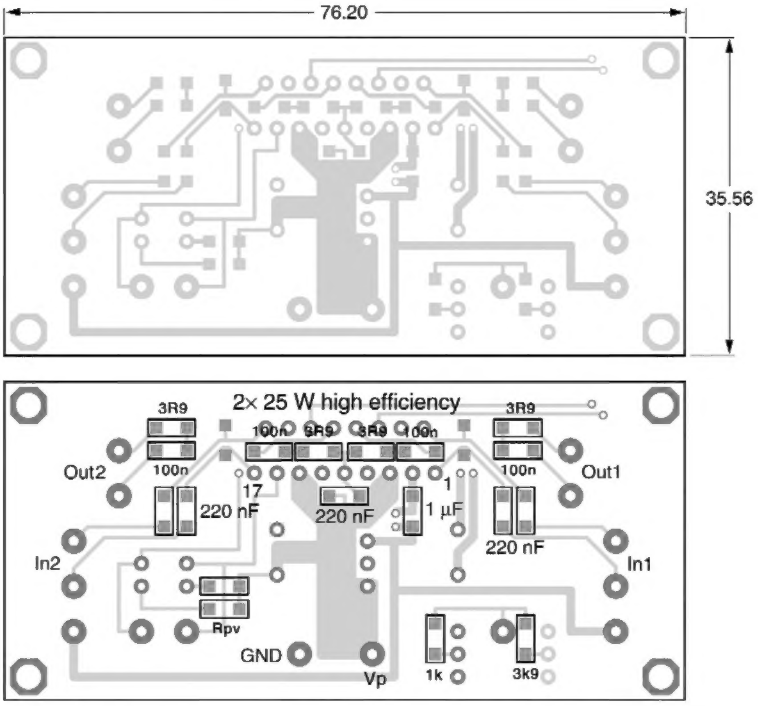

Dimensions in mm.

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Figure 3. This printed circuit board can be use for more than just experimenting!

Protection and diagnosis

That's enough for now on the subject of signal handling. The TDA1563Q, like many car audio output stages, also has a number of diagnostic and protection functions.

- **Thermal protection**. If the die temperature of the TDA1563Q rises above 150 °C, the output power is automatically limited to 5 W per channel.

- **Short circuit protection**. The amplifier is protected against short-circuiting of the outputs to ground, the positive supply voltage and each other. In case of a long-term short circuit to a supply voltage, the output stages are switched off for the duration; in case of a short-circuited loudspeaker the output stages switch alternately on and off. The 'on' time is short enough to avoid excessive power dissipation.
- The TDA1563Q has **three operating modes**, namely the Standby mode with a current consumption of less than 50 µA, the Mute mode (audio signal interrupted at the amplifier input) and the normal operating mode (On). The voltage applied to pin 6 (MUTE) determines the operating mode:

< 1 V:	Standby
2–3 V:	Mute
> 4 V:	On

  If an audio signal is present, an integrated zero-crossing detector prevents switching from Mute to On or from On to Mute at any time other than a zero crossing. This prevents 'plopping' when switching modes. However, if the supply voltage drops below 6 V (for example, when starting the motor), the IC immediately switches to the Mute mode.

- The TDA1563Q has **two diagnostic outputs**. Both pins are open-collector outputs and require pull-up resistors. The CLIP output is Low when the THD figure is greater than 2.5% (if the SC input voltage is between 1.8 and 18 V) or 10% (if the SC voltage is less than 0.5 V).
  The second output (DIAG) is Low when a short circuit is present, for the duration of automatic muting while the IC is being switched on or off and if the temperature warning threshold of 145 °C has been reached (at 150 °C, bridge mode operation is disabled).

Application example

Figure 3 shows the layout of a double-sided circuit board for the application circuit shown in Figure 2. The layout comes from the Philips data sheet. Except for the two electrolytic capacitors, all components are SMD types, which not only saves space in the radio bay but also reduces sensitivity to interference. Nevertheless, fitting the components is not particularly difficult. Be careful not to overlook the through connections! No values are given for the two resistors R_{PU} connected to the diagnostic outputs. These values must be chosen according to the logic voltage used and can be easily calculated from the fact that the current sunk by an active output is 2 mA.

The operating mode is controlled by two switches (On/Off and /Mute). The component values for the voltage divider are selected to apply a suitable voltage to pin 6 for each mode.

Due to its compact construction, this application example is suitable for use in active car sound systems, in which each loudspeaker needs its own amplifier. The TDA1563Q forms an ideal match for an efficient loudspeaker (such as a horn), and such a combination can be operated all day from a car battery without any charging current from the motor.

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